AMPLIFIER-DISCRIMINATOR FOR DRIFT CHAMBERS

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ABSTRACT

A drift chamber amplifier-discriminator for the K-e elastic scattering experiment is described. The lowest input threshold setting of the discriminator is 2 μA and the time slewing is 3.2 nsec. Four identical channels were located on one PC board to be mounted directly on the drift chamber.

In recent years drift chambers have generated remarkable interest for many physicists[1-3] because of their high resolution and modest cost. However, the spatial resolution of the chambers to date is generally limited by the time resolution of the electronics. On the other hand, the wire spacing covers a relatively large area, so that reasonably high signal rates must be tolerated. To provide these requirements the drift-chamber amplifier should be characterized by low threshold, the lowest possible time slewing and a wide bandwidth. In describing the design an effort was made to satisfy indicated conditions. A special test feature was also added. The amplifier was designed to be mounted directly on the drift chambers to obtain maximum circuit sensitivity. This amplifier-discriminator was made for a Drift Chamber System[4-6] used in the E456 K-e form factor experiment at the Fermilab accelerator.

A block diagram of the discriminator[7-9] is shown in Fig. 1. The circuit consists of several stages. The input protection network (D_1, D_2) assures against high-voltage breakdowns originating on the drift chamber sense wire and protects the very sensitive input transistor. There are two amplifying stages separated by a differentiating network. The first stage was based on discrete elements.[8] This makes it convenient to build up a current amplifier and also optimizes it for input noise level. A wire signal of the drift chambers behaves as a current source and therefore no useful signal is lost when the first stage of the amplifier is a current amplifier. The optimal load for the wire was determined to be 300 ohms.[10] Thus this impedance value was adopted. Transistors of the type 2N3563 and

2N5771 with f_T values of 600 and 850 MHz respectively were chosen. The current amplification of the input stage is given by $(R_4 + R_6)/R_4 \simeq 4$.

To provide high double pulse resolution particular care must be taken to assure the proper differentiating time constant. The optimal time constant was found empirically to be $C_5 \cdot R_{10} = 20$ nsec (Fig. 2). In Fig. 3 are shown drift chamber[4] signal shapes using a ^{55}Fe source. Figure 3(a) shows signals after the linear input stage (the amplifier inverts the pulse). The long (> 100 nsec) trailing edge of the pulse is due to ions coating around the wire. This effect could increase the dead time of the electronics because of the low amplifier threshold. Figure 3(b) shows a pulse shape after the differentiating network. The differentiation converts the trailing edge into a small negative pulse overshoot which is below the threshold. This is indispensable to avoiding multitriggering. The R_7, C_3, C_4 network decouples the very sensitive input stage from the remaining part of the amplifier. The second circuit stage of the amplifier was based on an MC 10216 integrated circuit differential amplifier.[11] The R_{13}, C_7, C_8 dc negative feedback stabilizes the operating point of the stage. The threshold of the circuit is adjusted by a 23-turn trimming pot and may be set from 2 μA to 6 μA. This stage gives 37 dB voltage amplification. For the discriminating network the 4.7 mA 1N3717 tunnel diode with buffering C section of the MC 10216 was adopted. The T_3, T_4 differentiating pair serves as an output standard NIM pulse generator. Such a solution, as opposed to another treatment with the emitter follower, eliminates current changes on power lines which are dangerous sources of cross-talks and instabilities. This gives a very "quiet" amplifier with -66dB cross-talk on the neighboring channel. The test feature of the amplifier permits the simultaneous checking of all channels, and also the entire system from the wire to the computer. A 16 mA external NIM pulse is attenuated to 80 μA input current (Fig. 2).

Figure 4 shows the variations of the output time as a function of input current. The time slewing between $\times 2$ and $\times 20$ overthreshold current values is 3.2 nsec. In Fig. 5 the internal recovery time of the entire amplifier depending on input current is displayed. As shown in the figure the circuit begins to approach saturation at approximately 300 μA input current. In the nonsaturated range the recovery time is about 6 nsec and the input-output delay at 100 μA input current is 6.5 nsec. The amplifier-discriminator consumes about 110 mA per channel at -6V power supply voltage. Four amplifier channels are located on one PC board (11 cm $\times$ 11 cm), one side of which is fully metalized (Fig. 6).

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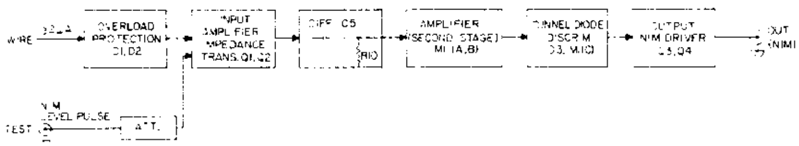


Fig. 1. Functional block diagram of the amplifier.

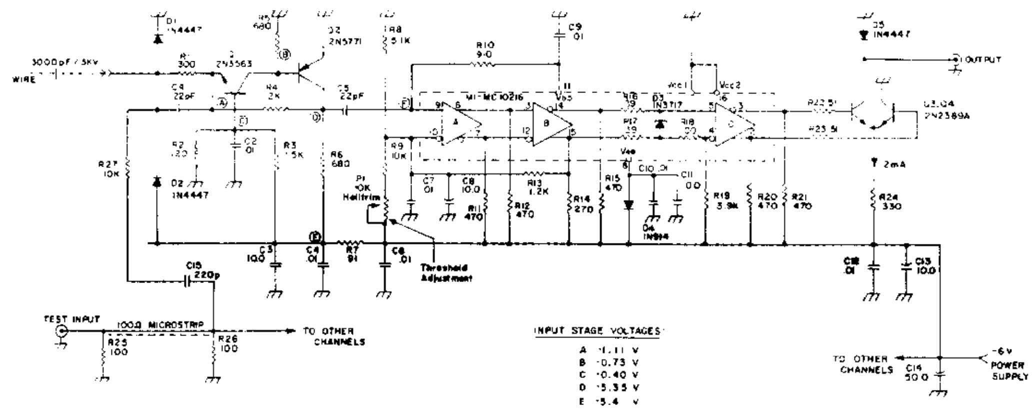
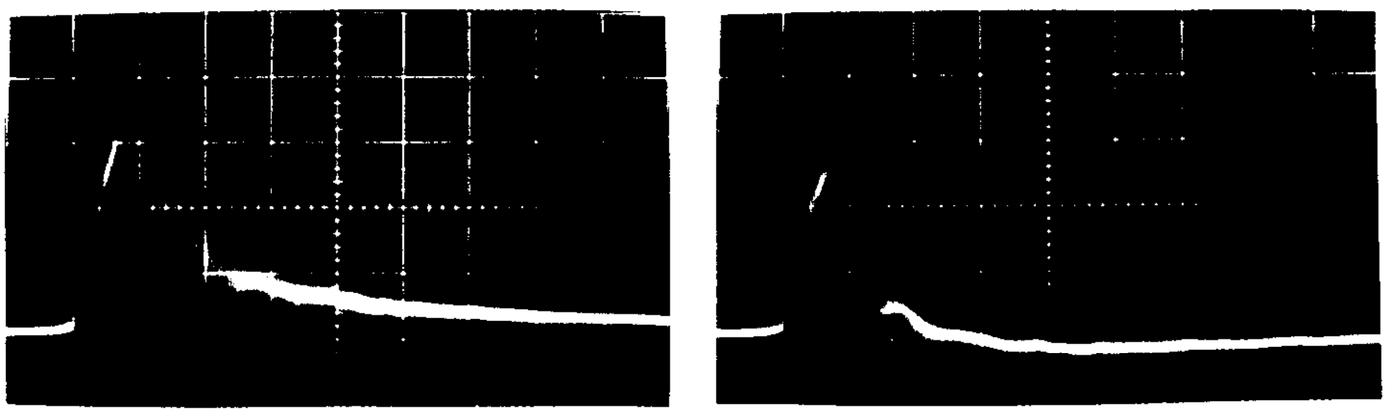


Fig. 2. Detailed circuit diagram.



(a) (b)

Fig. 3. Drift chambers signal shapes from a ^{55}Fe source at an anode potential +1.7 kV. (a) Signal after discrete, amplifying stage (point D) (horizontal scale: 10 nsec/div., vertical scale: 200 mV/div.) (b) Signal after differentiating network (point F) (horizontal scale: 10 nsec/div., vertical scale: 100 mV/div.).

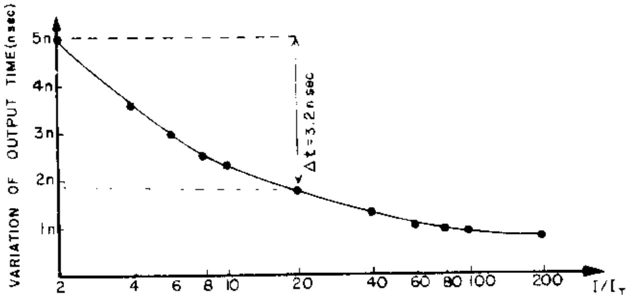


Fig. 4. Time slewing relations, Input pulse rise time less than 250 psec (Tektronix type 109 Generator).

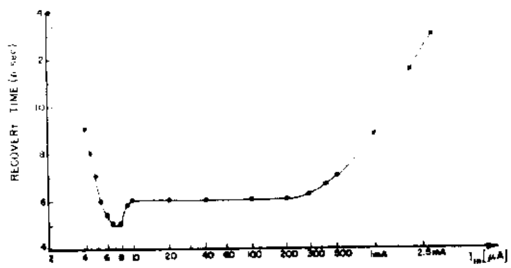


Fig. 5. Recovery time relations.

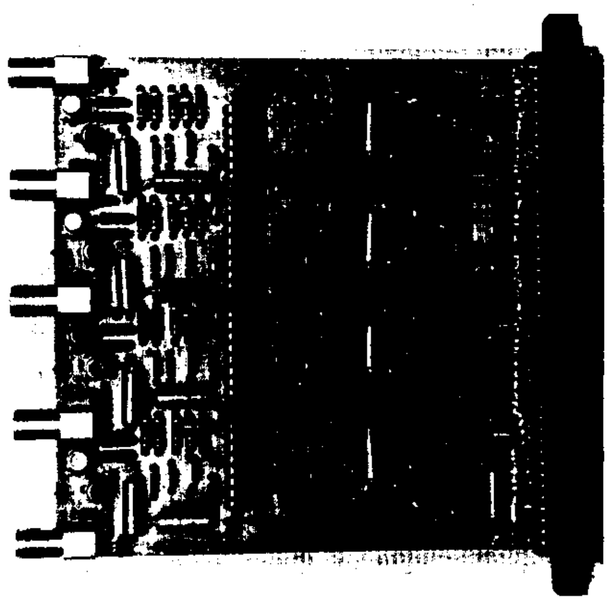


Fig. 6. Printed circuit board external view.